

## SHORT COMMUNICATION

# LONG-TERM CHANGES AND SEASONAL PATTERNS IN POSSUM (*TRICHOSURUS VULPECULA*) LEAF DIET, ORONGORONGO VALLEY, WELLINGTON, NEW ZEALAND.

**Summary:** Possum leaf diet from 1976 to 1989 in the Orongorongo Valley was compared with the diet recorded from four previous years, using faecal analysis. There were large differences in the proportions of species eaten in different seasons and between different years. There was little overall change in the proportion of the main diet tree species, *Metrosideros robusta* and *Weinmannia racemosa*, and seasonal increases or declines in one were usually balanced by opposite changes in the other. However, the results of a study of forest composition in the same area showed that living stems of both species declined substantially in abundance, the former mostly before 1978. *Melicytus ramiflorus* maintained both an important contribution to the diet and its stem density in the forest. The lianes *Metrosideros fulgens* and *Ripogonum scandens* both increased their proportion of the diet, but no data were available on their abundance in the study area. At present browse levels, *Weinmannia racemosa* will become extinct locally, and *Metrosideros robusta* more rare, especially if drought and higher than average possum densities coincide. Given their large contribution to possum diet, the decline of these species will have a significant effect on possum feeding habits, including increased browsing pressure on *Melicytus ramiflorus*, *Ripogonum scandens* and *Metrosideros fulgens*. The trend for formerly less palatable tree species to replace those previously important in the diet will continue, with consequent changes in forest species composition.

**Keywords:** Brushtail possum; *Trichosurus vulpecula*; diet; season; variation; species composition; forest.

## Introduction

Five or fewer forest plant species commonly provide 50–90% of introduced Australian brushtail possum diet in New Zealand (Green, 1984) and Tasmania (Fitzgerald, 1984). Diet preferences result in some species being eaten in amounts disproportionate to their abundance (Fitzgerald, 1976; Leathwick, Hay, and Fitzgerald, 1983). As selective browsing reduces the abundance of preferred plant species, formerly less preferred species can become dominant in the diet (Green, 1984).

The diet of possums has been documented in the Orongorongo Valley since 1958 (e.g., Mason, 1958; Fitzgerald, 1976; Cowan, 1990). Leaves comprise over 60%, and flowers, flower buds, fruits, seeds, bark and petioles about 35%, of the total possum diet in the study area (Fitzgerald, 1976). We report changes in possum seasonal leaf diet over 14 years (1976–1989) in the Orongorongo Valley, and compare these with the earlier (1969–1973) results of Fitzgerald (1976) from the same area. During the 14 year period, possum densities remained relatively stable in the study area at around the long-term mean

of 9 ha<sup>-1</sup> (M.G.E., unpubl. data). Vegetation surveys were carried out in 1978 and 1985 (Campbell, 1990). We use the results of these to determine if trends in the leaf diet of possums are related to changes in the abundance of tree species.

## Study area

The Orongorongo Valley is located 18 km east of Wellington (41°21'S, 174°58'E). The study area of 4.4 ha is located at about 100 m a.s.l., and comprises forest with scattered emergent *Metrosideros robusta*<sup>1</sup> and *Dacrydium cupressinum* over a canopy of *Elaeocarpus dentatus*, *Laurelia novae-zelandiae*, *Melicytus ramiflorus*, *Hedycarya arborea*, *Knightsia excelsa*, *Weinmannia racemosa*, *Schefflera digitata* and *Pseudowintera axillaris*. Understorey small trees, shrubs and lianes include most canopy species,

<sup>1</sup>Plant nomenclature follows Allan (1961) and Connor and Edgar (1987).

*Coprosma* species, *Carpodetus serratus*, *Geniostoma ligustrifolium*, *Macropiper excelsum*, *Myrsine australis*, *Olearia rani*, *Metrosideros fulgens*, *M. diffusa*, *M. perforata*, *Ripogonum scandens*, and *Freycinetia baueriana banksii*. More complete descriptions are provided by Fitzgerald (1976) and Campbell (1990).

## Methods

### Faecal analysis

Single faecal pellets were collected from possums trapped on the first night of trapping within the study area each year in February, June, and September, during routine trapping and release for a population monitoring study. For each collection, 25-30 pellets

were fragmented together in a blender, passed through a 210  $\mu\text{m}$  sieve, macerated in a 1:2 diluted 60:40 nitric-chromic acid mixture, washed and neutralised, then stained with basic fuchsin (Fitzgerald, 1976). Stained samples were examined under a microscope, and abaxial leaf cuticle fragments were identified by AEF by comparison with reference slides. For each faecal sample, the horizontal width of each of 400 fragments was recorded with an eyepiece graticule to give an estimate of relative area. Fragment weight was calculated from area, corrected for digestibility using the method of Dunnet, Harvie, and Smit (1973), and used to estimate the proportion of diet made up by each of the main leaf species in possum faeces in February, June and September, and for the three combined, from 1976 to 1989. There was no June sample in 1987, and the last samples analysed were from February 1989.

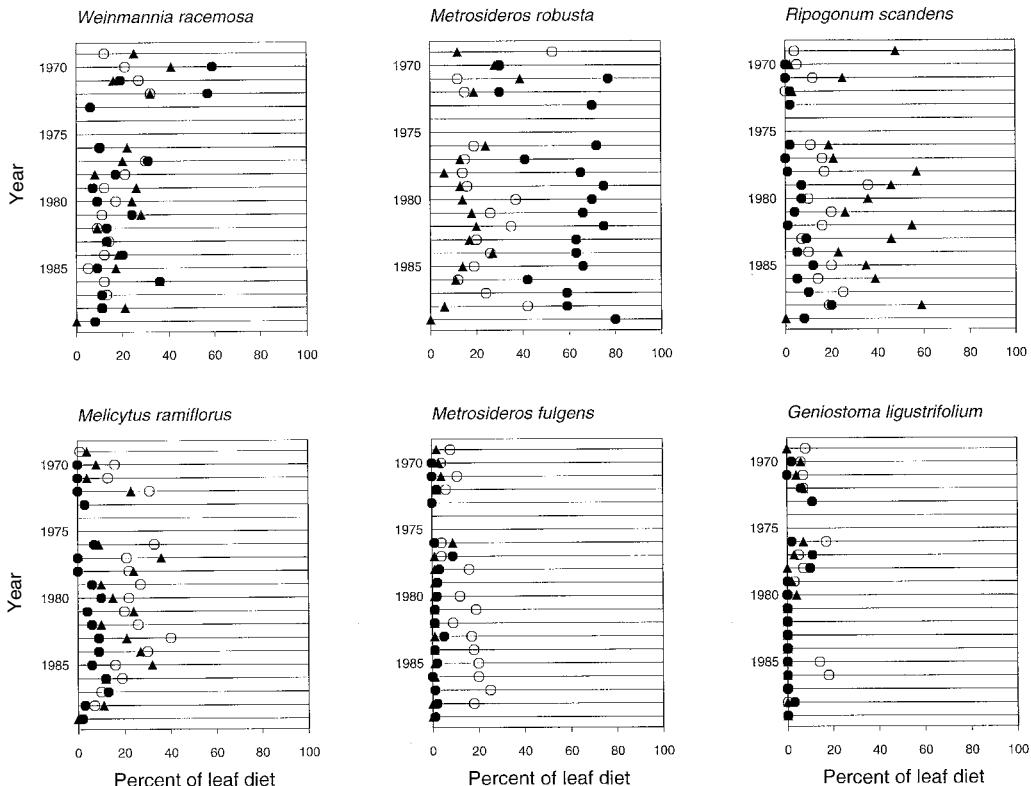


Figure 1: Proportions (% of diet by weight in possum faeces, corrected for digestibility) of species contributing >10% of the leaf diet (*Geniostoma ligustrifolium*, *Ripogonum scandens*, *Melicytus ramiflorus*, *Metrosideros fulgens*, *Metrosideros robusta*, *Weinmannia racemosa*) in February (filled circles), June (triangles) and September (empty circles), from June 1969 to February 1973 (Fitzgerald, 1976), and from February 1976 to February 1989. There was no June sample in 1987.

## Analyses

The test of van Belle and Hughes (Gilbert, 1987) was used to determine whether trends in the proportion of diet over the study period were similar between the three seasonal samples for each species. Where trends differed between seasonal samples, nonparametric Mann-Kendall tests (Gilbert, 1987) were applied to each seasonal data set separately to determine whether there were significant trends in the proportion of diet over the study period for each species. Where trends were similar, pooled Kendall trend tests were applied to the combined seasonal data to determine significant trends over the study period.

## Results

### Plant components of the diet

Ten major food plant species were previously recorded contributing to possum leaf diet in this area (Fitzgerald, 1976). In the present study, over 80% of the leaf diet as represented by abaxial fragments in all faecal samples came from six of these species: *Metrosideros robusta*, *M. fulgens*, *Weinmannia racemosa*, *Ripogonum scandens*, *Melicytus ramiflorus*, and *Geniostoma ligustrifolium* (Fig. 1). Of the other four, *Laurelia novae-zelandiae* and *Pseudopanax arboreus* never contributed more than 10% of the diet. *Beilschmiedia tawa* and *Elaeocarpus dentatus* exceeded 5% only twice between 1969 and 1973, and were insignificant or absent from 1976 to 1989. The overall contribution of these and other minor species making up the balance of the leaf diet declined from 1969 to about 1978, then remained relatively constant at generally less than 5% in any season (Fig. 1).

### Patterns of change in leaf diet

*Metrosideros fulgens* was the only species that did not show similar trends in abundance in the diet between the three seasons through the study period (Table 1). The *M. fulgens* seasonal samples showed no evidence of change in February ( $P=0.72$ ), a significant decline in June ( $P<0.001$ ), and an increase in September ( $P=0.002$ ).

Significant declines occurred over time in the overall (three seasons combined) percentage of diet

Table 1: Results of the van Belle and Hughes test for seasonal homogeneity of trend in percentage of diet over time, and of pooled Kendall tests for trends in the percentage of diet provided by six species. All  $P$  values are for two-sided tests.  $S$  is the statistic for trend.

Species	test of homogeneity		pooled test for trend over time	
	$\chi^2$	$P$	$S$	$P$
<i>Metrosideros robusta</i>	2.46	0.29	-30	0.50
<i>Weinmannia racemosa</i>	1.40	0.50	-90	0.04
<i>Ripogonum scandens</i>	1.25	0.53	196	<0.001
<i>Melicytus ramiflorus</i>	3.62	0.16	91	0.04
<i>Metrosideros fulgens</i>	21.87	<0.001	12	0.79
<i>Geniostoma ligustrifolium</i>	0.47	0.79	-147	<0.001

provided by *Weinmannia racemosa* and *Geniostoma ligustrifolium*, and significant increases in *Ripogonum scandens* and *Melicytus ramiflorus*, but changes for *Metrosideros robusta* and *M. fulgens* were not significant (Table 1).

### Seasonal variation in leaf diet

#### February diet

From 1976 to 1989, *Metrosideros robusta* consistently provided about 40-80% of the diet in February (Fig. 1), and *Weinmannia racemosa* some 5-35% of the remainder after a peak of about 60% in 1970 and 1972. Neither *Ripogonum scandens* nor *Melicytus ramiflorus* appeared until February 1972, and there was a slight overall trend for both to increase in the February diet thereafter. The February contribution of *Metrosideros fulgens* varied without apparent pattern following its first appearance in 1972. *Geniostoma ligustrifolium* disappeared from the February diet after 1978 until its brief reappearance in 1988.

#### June diet

*Ripogonum scandens* made a major contribution to the June diet in 1969 (50%) and 1971 (30%), and again from 1976 to 1988 (20-60%). *Melicytus ramiflorus* was a dominant component of the diet in 1972 (c. 20%), and from 1977 (10-35%). *Metrosideros robusta* (5-40%) and *Weinmannia racemosa* (5-40%) were also important in most years. *Metrosideros fulgens* made a small contribution every year except 1976 and 1988. *Geniostoma ligustrifolium* declined after 1972, and disappeared from the June diet in 1981.

### September diet

Apart from its near absence in 1972, *Ripogonum scandens* contributed a substantial proportion of the September diet, rising to more than 20% in several years. *Metrosideros fulgens* increased after 1977, from 5-10% to 10-20% of the diet. *Melicytus ramiflorus* increased from near-absence in 1969 to a peak of 40% in 1983. After a peak of more than 50% in 1969, *Metrosideros robusta* contributed about 10-40% of the September diet from 1970 to 1988, its contribution changing inconsistently between years. The contribution of *Weinmannia racemosa* to the September diet increased from 10% to nearly 40% from 1969 to 1972, but declined to vary from about 10% to 20% from 1976 to 1988. *Geniostoma ligustrifolium* made up about 10% of the diet from 1969 to 1972, peaked at about 20% in 1976, then declined to zero after 1979 until a marked but brief reappearance at more than 10% in 1985 and 1986.

## Discussion

### Abundance of diet species

Campbell (1990) presented density and basal area data for tree species in the study area, for the three years 1969, 1978, and 1985. These can be used to give an indication of some changes in food availability relative to possum diet and the effects of possum browsing.

The two major diet species, *Metrosideros robusta* and *Weinmannia racemosa*, showed a decline in stem density and basal area from 1969 to 1985, along with an increase in the mean basal area of individual stems (calculated from Table 1 of Campbell, 1990) which indicates decreased recruitment (Fig. 2). There was no overall decline in the proportion of *M. robusta* in possum diet, so the remaining trees must have suffered increased browsing levels over this period.

Another important diet species, *Melicytus ramiflorus*, increased in density and basal area (Campbell, 1990). Its small and constant mean basal area per stem indicates that size class distribution, and thus recruitment into each class, remained constant.

The density and basal area of *Beilschmiedia tawa*, a species formerly important in possum diet, declined almost to extinction (Campbell, 1990). According to Brockie (1992), the Orongorongo Valley is only marginally suitable habitat for this species, so little additional stress from possum

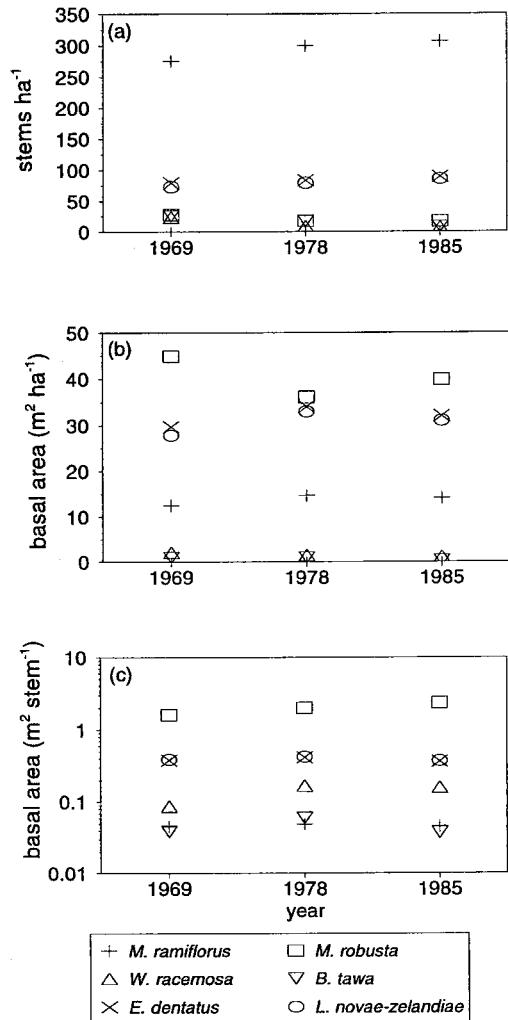


Figure 2: Trends in density (a), total basal area (b), and mean basal area per stem (c), of the main diet tree species (*Melicytus ramiflorus*, *Metrosideros robusta*, *Weinmannia racemosa*), along with other canopy tree species which have declined (*Beilschmiedia tawa*) or increased (*Elaeocarpus dentatus*, *Laurelia novae-zelandiae*) over the study period (based on data from Table 1 of Campbell (1990)).

browsing may have been required to precipitate its demise.

Density and basal area data are not available for the two lianes which are prominent in possum diet: *Ripogonum scandens* and *Metrosideros fulgens*. However, Brockie (1992) noted that *R. scandens* stems visible in the forest canopy were almost

completely defoliated by the end of winter, indicating high browsing pressure.

In contrast to the declines in the two major diet species, two species that are insignificant in possum leaf diet, *Elaeocarpus dentatus* and *Laurelia novae-zelandiae*, followed almost identical patterns of increasing density, whilst maintaining the constant mean basal area per stem that indicates a stable population size class structure. Fruits of *E. dentatus* are a significant component of possum diet in autumn and winter, and their abundance affects possum reproduction and body weight (Cowan, 1990). Increases in its abundance may partly offset the negative effects on possum densities from declines in favoured leaf diet species.

Although the percentage contribution to the diet of individual components other than leaves has not been quantified, it can be substantial. Cowan (1990) noted that flowers of *Elaeocarpus dentatus*, *Knightia excelsa*, *Macropiper excelsum*, *Rhopalostylis sapida*, and the introduced *Ulex europaeus*, were eaten consistently, along with the fruits of almost all species available, with few particular preferences. Possums have also been recorded eating flowers of *Hedycarya arborea*, *Metrosideros robusta*, and *M. fulgens* (Fitzgerald, 1978). Possum consumption of plant reproductive structures may contribute to declines in the density of favoured leaf diet species by reducing seed production and thus plant recruitment.

### Seasonal variation in diet

Distinctive seasonal consumption patterns of plant species by possums have been noted previously, and ascribed to seasonal availability or palatability of leaves (Owen and Norton, 1995), differing seasonal requirements to achieve a diet balanced in proteins and fats (Gilmore, 1967), or the need to offset the effects of plant toxins (Fitzgerald, 1978). In the present study, conspicuous examples of seasonally important plant species are *Metrosideros robusta* (high percentage of February diet), *Ripogonum scandens* (June diet), and *Metrosideros fulgens* (September diet). Fitzgerald (1978) indicated that *M. fulgens* is prominent in the diet when the lipid content of its leaves is high, and attributed overall diet preferences for *Weinmannia racemosa*, *M. robusta* and *M. fulgens* to their low content of toxic compounds relative to the less frequently eaten *R. scandens* and *Melicytus ramiflorus*. However, Fitzgerald's (1978) results did not reveal a relationship between seasonal diet preferences and seasonal variation in the presence of toxic compounds. The relationships between plant leaf

chemistry and possum seasonal diet preferences require further study.

### Implications for forest structure and possum behaviour

Fitzgerald (1976) noted that several tree species formerly more common in the study area had declined substantially in abundance or were locally extinct as a result of preferential browsing by possums. Notable examples were *Fuchsia excorticata*, *Alectryon excelsus*, *Pseudopanax arboreus*, *Myrsine salicina*, and *Beilschmiedia tawa*. Between 1969 and 1978, 36% of *Metrosideros robusta* stems in the study area died, along with 35% of *B. tawa*, and 64% of *Weinmannia racemosa* (Campbell, 1990). Heavily browsed *M. robusta* trees protected from possums recovered within a few years (Meads, 1976), confirming the role of possums in *M. robusta* decline. Of the stems remaining in 1978, 6% of *M. robusta*, 53% of *B. tawa*, and 22% of *W. racemosa* had died by 1985 (Campbell, 1990). Although the death rate for *B. tawa* increased over this period, Fitzgerald's (1976) suggestion that an increased death rate of *M. robusta* would result if possum intake of foliage did not decline was not confirmed. Cowan *et al.* (in press) linked the pre-1978 relatively rapid decline in *M. robusta* to exceptional stress caused by above average possum numbers and drought in 1969-1973. The more normal possum densities and rainfall thereafter reduced stress on *M. robusta*, and nearly all the remaining trees survived.

In 1985, 17 stems of *Metrosideros robusta*, eight of *Beilschmiedia tawa* and seven of *Weinmannia racemosa* remained in the 2.25 ha plot described by Campbell (1990). *B. tawa* was virtually absent from possum diet from 1979, probably because all mature trees had died and the remaining plants were small (Campbell, 1990). By 1985, much of the *W. racemosa* in possum diet was being taken from the foot slopes of the ridges adjacent to the study area (M.G.E.; *pers. obs.*), where *W. racemosa* is more abundant than in the study area. Given that the proportion of *M. robusta* and *W. racemosa* leaves in possum diet 1985-1989 remained similar to the levels recorded prior to 1985, browse levels on the surviving trees are unlikely to be sustainable, particularly if conditions such as those of 1970-1974 (Cowan *et al. in press*) recur. Death of the remaining stems may be inevitable. They are likely to be replaced by relatively unpalatable canopy species such as *Laurelia novae-zelandiae* and *Elaeocarpus dentatus*, as predicted by Campbell (1990).

Although changes in leaf diet and vegetation were not associated with marked changes in possum densities over the period of this study, substantial declines in the abundance of preferred food species should have consequences for possum population dynamics. Further research is required to determine the response of possum populations to such major changes in food resources.

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